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QUESTION 9 - ASSESSMENTS/INVESTIGATIONS

The following investigations have been performed at the site by Geraghty & Miller, Inc. for Allied.

1. In 1977, an investigation was conducted to evaluate the nature and extent of contamination beneath the South plant (Hanlin area) of the plant. Findings from this study indicated that groundwater quality had been affected by plant-related contamination.

2. In 1978, a similar type investigation was conducted at the North plant (Allied/Olin area).

3. In 1986 the groundwater flow patterns at the Allied/Hanlin/Olin Site were reevaluated. The study concluded that the pumping program at the Site was successfully preventing groundwater contaminants from migrating off-site.

   Copies of these three investigations have already been provided to U. S. EPA Region III.

4. In 1990 an evaluation was conducted of the existing groundwater monitoring well network and the containment system. A copy of the Executive Summary from the evaluation is attached.

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GROUND-WATER CONTAMINATION AT
ALLIED CHEMICAL CORPORATION
(SOUTH) PLANT SITE
MOUNDSVILLE, WEST VIRGINIA

September 19, 1977

Geraghty & Miller, Inc.
Consulting Ground-Water Geologists and Hydrologists
Water Research Building
Port Washington, New York 11050

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Geraghty & Miller, Inc.

CONSULTING GROUND-WATER GEOLOGISTS AND HYDROLOGISTS

Water Research Building
44 Sintsink Drive East
Port Washington, New York 11050
Cable: WATER

Telephone: 516/883-6760

September 19, 1977

Mr. E. J. Shields
Allied Chemical Corporation
P.O. Box 1087 R
Morristown, New Jersey 07960

Dear Mr. Shields:

We have completed our report concerning ground-water contamination in the southwest corner of Allied's Speciality Chemicals Division (South) Plant in Moundsville, West Virginia. We have concluded that contaminated ground water is, at present, not moving off-site in a southerly direction and will not do so in the future if Ranney Wells A and B are kept pumping continuously.

We thank you for the opportunity to provide our services. If you have any questions, please do not hesitate to contact me or Mr. George Wilson.

Sincerely,

GERAGHTY & MILLER, INC.

Nicholas Valkenburg

Nicholas Valkenburg
Hydrogeologist

NV/lcc
Enc.

Geraghty & Miller, Inc.
CONSULTING GROUND-WATER GEOLOGISTS AND HYDROLOGISTS
Water Research Building
44 Sintsink Drive East
Port Washington, New York 11050
Cable: WATER
Telephone: 516/883-6760

September 20, 1977

Mr. E. J. Shields
Allied Chemical Corporation
P.O. Box 1087 R
Morristown, New Jersey 07960

Dear Mr. Shields:

After mailing our report concerning ground-water contamination at Allied's Moundsville (South) Plant, I discovered an error in the way ground-water mercury concentrations were reported by us. The correct units for mercury concentrations should be MICROGRAMS PER LITER, not milligrams per liter as reported in Table 2, Figures 6 and 7 or parts per million as shown in Figure 4.

Please accept my apologies for this oversight. I hope you can correct the mistake before the reports are distributed. If you have any questions, please do not hesitate to contact me.

Sincerely,

GERAGHTY & MILLER, INC.

Nicholas Valkenburg

Nicholas Valkenburg
Hydrogeologist

NV/lcc
cc: Mr. George Wilson

Note: Above changes made in all copies.

E. J. [illegible]
9/28/77

Geraghty & Miller, Inc.

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GROUND-WATER CONTAMINATION AT ALLIED CHEMICAL CORPORATION (SOUTH) PLANT SITE MOUNDSVILLE, WEST VIRGINIA

Introduction

On March 23, 1977, Allied Chemical requested that Geraghty & Miller, Inc. perform a hydrogeological study at the Specialty Chemical Division's plant near Moundsville, West Virginia. The primary purpose of the study was to determine whether or not contaminated ground water that exists beneath the southwestern area of the plant could migrate to off-site wells, and if so, what remedial action should be taken to prevent this. A secondary purpose was to evaluate the overall ground-water contamination problem, generally, and to recommend action to be taken on abandoned ponds in particular.

The study began with a review of the available literature and plant data. Following this, a field investigation was performed which involved the installation of fourteen observation wells in which potentiometric levels of the ground water were measured and from which ground-water samples were collected for analysis. The following is a report of our findings, conclusions, and recommendations.

Summary and Conclusions

(1) A flow net (see Figure 1), constructed from ground-water elevation measurements, and water-quality data, (see Figures 3, 4, and 5, and Table 2) demonstrate that contaminated ground water is not migrating off the property to the south.

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(2) In order to assure complete and continued capture of contaminated ground water in the southwest corner of the plant site, Ranney Wells A and B should be pumped continuously.

(3) Ground water under most of the Moundsville plant site has become severely contaminated with organic and inorganic compounds from waste ponds and piles.

(4) The discharge of polluted ground water to the Ohio River can be minimized in the future by sealing new waste ponds, covering abandoned ponds with an impermeable material, continuing to pump the Ranney Wells, and installing strategically placed recovery wells.

Field Investigation

Fourteen observation wells were installed in the southwestern corner of the plant site between June 6, 1977 and June 15, 1977. The locations of the wells are shown in Figure 1. In each case, a hole approximately 7 inches in diameter was drilled using a hollow-stem auger, until the water table was encountered. A water sample was then collected using a bailer. Drilling was resumed for an additional ten to twenty feet, where possible, and a well point on riser pipe was driven through the end of the auger bits into the aquifer to collect a ground-water sample at an intermediate depth between the water table and bedrock. After the sample was collected, the hole was drilled to bedrock and the well point was permanently set. Each well was completed by packing sand around the well point, setting a bentonite seal to prevent surface contamination from entering the well, then backfilling the well with drill cuttings. Figure 2 shows the construction of Observation Well 8,which is typical of the construction of all the observation wells, and Table 1 shows the depth of the

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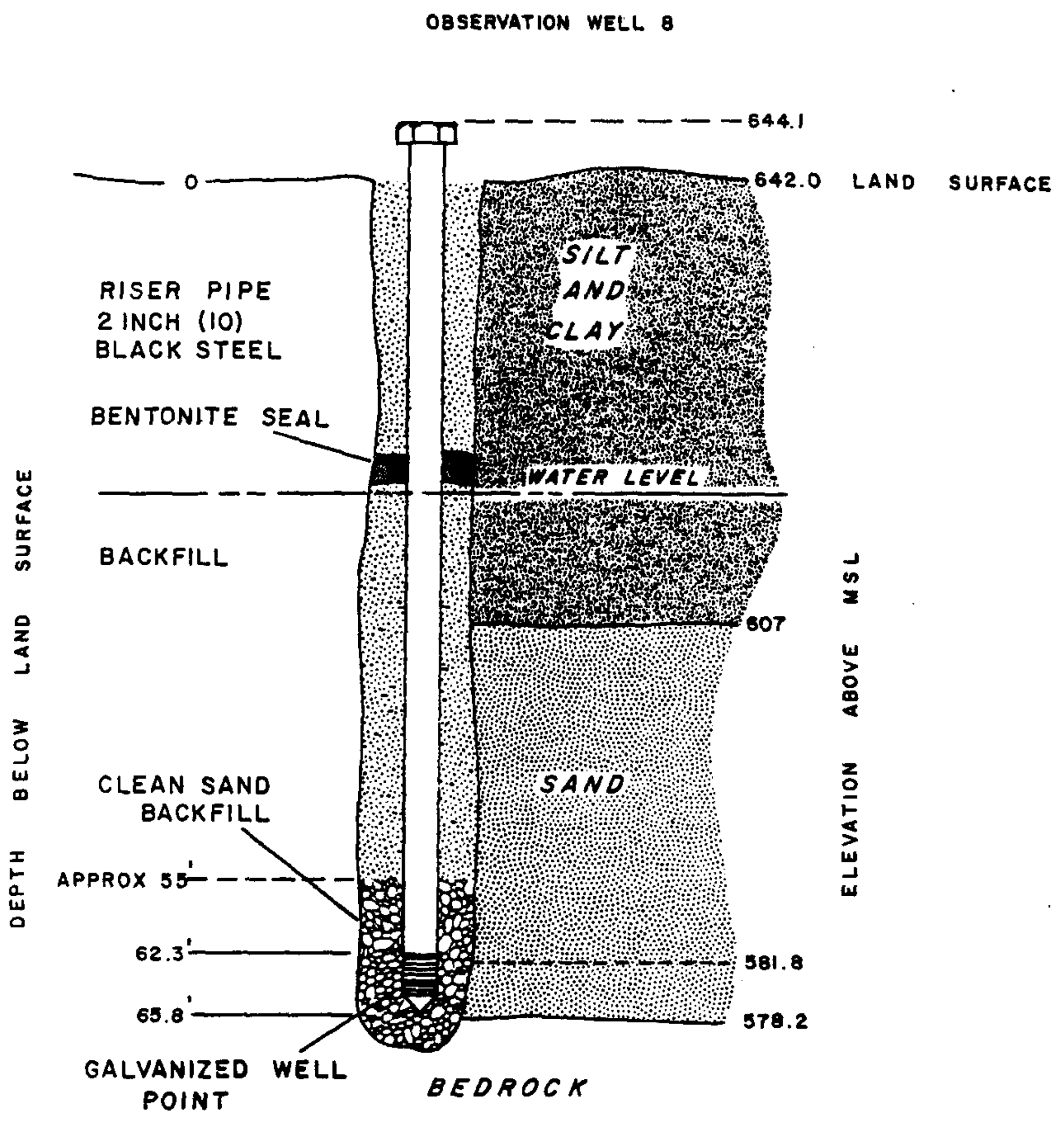

FIGURE 2

TYPICAL CONSTRUCTION OF OBSERVATION WELLS

ALLIED CHEMICAL CORP., MOUNDSVILLE
SOUTH PLANT, WEST VIRGINIA

TABLE 1

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Summary of Statistics for Observation Wells

Well No.	Depth [a]	Well Point Setting [a]	Elevation [b] of Top of Casing	Elevation [b] of Well Point	Depth [a] to Water	Elevation [b] of Static Water Level [c]
1	38.2	34.7-38.2	706.93	672.2-668.7	32.0	672.9
2	75.0	71.5-75.0	700.29	628.8-625.3	58.8	639.4
3	94.6	91.1-94.6	689.96	598.9-595.4	68.3	618.1
4	85.4	81.9-85.4	669.58	587.7-584.2	50.0	617.3
5	94.6	91.1-94.6	671.56	580.5-577.0	52.5	616.0
6	69.9	66.4-69.9	642.66	576.3-572.8	25.7	615.7
7	69.7	66.2-69.7	643.33	577.1-573.6	25.5	616.0
8	65.8	62.3-65.8	644.13	581.8-578.3	24.8	617.3
9	64.0	60.5-64.0	642.17	581.7-578.2	21.5	618.7
10	84.7	81.2-84.7	668.43	587.2-583.7	46.9	618.9
11	96.2	92.7-96.2	680.30	587.6-584.1	59.2	619.2
12	94.3	90.8-94.3	694.37 ~~693.81~~	603.0-599.5	70.8	619.9
13	89.1	85.6-89.6	705.16	619.6-616.1	66.4	635.1
14	85.5	82.0-85.5	685.97 ~~686.46~~	604.5-601.0	64.8	619.3
R.T. 1 [d]	32.5	unknown	642.95	unknown	24.2	618.7
R.T. 2 [d]	72.7	unknown	642.64	unknown	22.2	619.9

a) Below land surface (in feet)

b) Above mean sea level (in feet)

c) As measured on June 14, 1977

d) Ranney Test Wells

wells in addition to depth to water measurements. A final water sample was collected from each well after the well point had been set permanently. The results of chemical analyses performed on all the water samples are shown in Table 2.

Water samples were also collected from a well serving the Moundsville Country Club, which is located approximately 1,000 feet south of the fence-line border between the golf course and the Allied property, in order to determine whether contamination from the ponds was moving in that direction. The potable water supply at the plant was also sampled in order to ascertain whether contaminated water had traveled beyond the golf course well and had reached the wells in the Washington Lands public supply system. Finally, a sample from a spring in the wall of a pond dike (see Figure 1) that was thought to be chemically similar to leachate leaving the ponds and entering the ground-water system. The results of analyses on these samples are also shown in Table 2.

Findings

Ground-water flow directions inferred from potentiometric water levels measured in the observation wells demonstrate that contaminated ground water beneath the ponds moves toward the Ranney Wells in a radial pattern due to the influence of pumpage from the wells (see Figue 1). While the Ranney Wells are pumping, there is virtually no possibility that contaminants entering the ground water in leachate from the waste disposal ponds in the southwest corner of the plant area will migrate south and off the property.

The almost complete capture of ground-water contaminants by Ranney Wells A and B is corroborated by chemical evidence in Figures 3, 4 and 5. These maps were produced by

Table 2. Results of Water Quality Analyses. (Concentrations are in milligrams per liter, except where noted.)

Well No.	Sample Number	Sample Depth[a]	Total Hardness as $CaCO_3$	pH	Manganese	Mercury[g]	Sulfate	Specific Conductance[b]	Chloride	Methylene Chloride[c]	Chloroform[c]	Carbon Tetrachloride[c]
1	6-1	41	144	8.2	1.09	0.46	ND[d]	320	23	< 0.1	< 0.1	< 0.2
2	5-1	70	159	8.1	3.26	0.74	ND	390	69	0.4	2.6	0.8
2	5-2	76	159	8.3	6.52	0.22	ND	370	58	< 0.1	4.0	3.0
3	10-1	80	5788	5.8	100	1.22	1790	21500	14954	10000	8950	16880
3	10-2	97	5335	7.2	107.2	0.58	1300	19000	13689	27813	65000	75000
4	8-1	55	2640	7.1	40.8	0.54	1490	9000	4170	780	3900	> 50
4	8-2	85	3544	7.1	45.8	0.86	1750	13000	8167	22200	29700	392
5	7-1	60	3744	7.0	13.6	2.08	372	23000	16679	207	2213	123
5	7-2	95	18907	6.7	30.8	2.76	725	60000	71895	1912	47590	750
6	14-1	30	474	7.3	3.56	0.56	632	4750	2331	7.5	2340	650
6	14-2	50	1420	7.6	15.0	0.52	750	1960	5209	5400	17100	246
6	14-3	65	5647	6.7	63.2	0.76	1270	28500	21354	8600	19000	1128
7	13-1	30	724	7.3	0.40	1.44	104	2500	1196	5.0	563	48
7	13-2	50	246	7.9	0.3	0.12	103	1900	771	0.88	57.8	10
7	13-3	65	1441	7.5	14.0	0.76	365	16000	10696	247	555	7
8	12-1	30	206	8.0	0.19	0.74	89	670	161	0.5	96.5	17.5
8	12-2	50	250	8.2	1.46	0.44	94	660	115	3.8	80	0.25
8	12-3	65	237	8.1	0.36	0.38	97	505	69	0.7	26	6.0
9	11-1	30	137	7.4	0.74	0.28	43	450	52	2.4	2336	5.2
9	11-2	50	661	7.5	2.8	0.02	138	4100	2047	-	-	-
9	11-3	65	243	8.1	0.22	0.26	79	660	150	2.4	75	8.0
10	1-1	49	318	8.1	1.67	0.44	140	640	57	5	66	0.3
10	1-2	70	200	8.1	0.38	0.34	95	485	51	0.2	1.5	1.6
10	1-3	94	309	8.2	2.44	0.44	90	920	328	4	138	4.3
10	1-4	85	205	7.9	2.1	2.24	85	520	75	30	18	17
11	2-1[e]	65	318	8.3	1.0	19.5	35	340	34	< 0.1	22	5.4
11	2-2	85	271	8.4	0.43	0.22	50	315	34	< 0.1	30	1.0
11	2-3	98	359	8.4	1.43	0.24	72	700	144	0.3	25	0.4
11	2-4	96	234	7.9	2.7	0.06	85	110	63	6	17	1

a) Below land surface (in feet)
b) micromhos/cm
c) Concentrations in parts per billion
d) Not detected
e) Sample contaminated with oil from vacuum pump

g) micrograms/liter

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Table 2. Continued

Well No.	Sample Number	Sample Depth[a)]	Total Hardness as $CaCO_3$	pH	Manganese	Mercury (g)	Sulfate	Specific Conductance[b)]	Chloride	Methylene Chloride[c)]	Chloroform[c)]	Carbon Tetrachloride[c)]
12	3-1	79	4321	7.4	43.6	0.28	141	18000	12164	190	5692	57
12	3-2	97	640	7.7	6.48	0.1	36	2200	949	14	896	4.0
13	4-1	83	421	8.1	2.06	0.04	63	700	172	0.2	7.3	1.7
14	9-1	84	318	8.1	0.5	0.2	52	1170	541	-	-	-
Golf Course Well 5/31		-	190	7.9	ND	0.18	70	600	46	-	-	-
Golf Course Well 6/17		-	-	-	-	ND	-	500	-	<0.1	0.3	0.1
Tap Water			237	7.4	ND	0.04	-	520	40	-	-	-
Tap Water 6/24		-	-	-	-	ND	-	-	-	<0.1	< 0.1	< 0.1
	0-1 f)		3026	11.7	0.2	109	2868	70000	70170	414	116	21

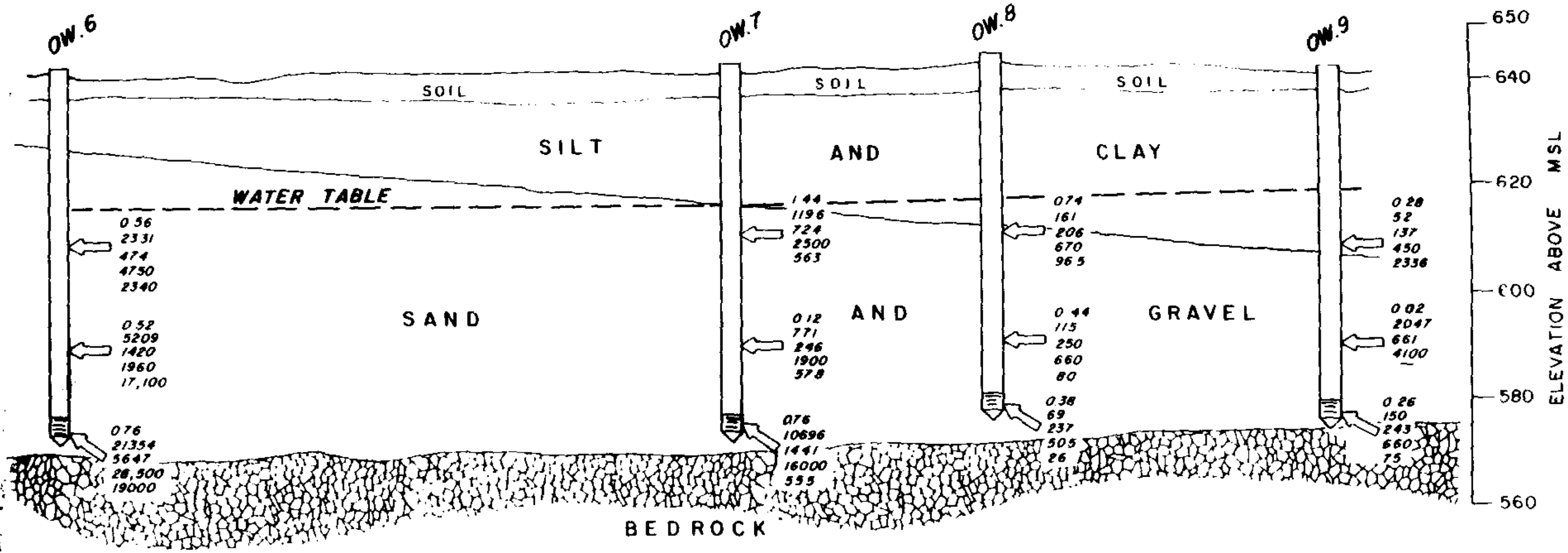
f) Sample from spring in dike (see Figure 1)

g) Micrograms/Liter

determining the mean concentration of a chemical constituent from all the water samples obtained from a particular well, plotting these averages, then contouring them. It can be seen that contaminant concentrations decrease very rapidly toward the south while they attenuate much less rapidly toward the northwest. Figures 3, 4, and 5 illustrate the assertion that contaminated ground water moves away from the immediate area of the ponds toward the Ranney Wells and not toward the south. Finally, there is no chemical evidence, at present, that contaminated ground water has traveled south, either to the golf course well or the Washington Lands Wells. Water quality analyses (see Table 2) from both sources show that concentrations of substances for which analyses were performed appear to be well within natural limits.

Figures 6 and 7 are two geologic cross sections, one in a north-south direction and one in a west-west orientation. These were constructed to determine the vertical extent and distribution of ground-water contamination. Water-quality data on these figures appears somewhat confused, however, and no vertical pattern of contamination can be discovered, except that Figure 6 shows higher concentrations of contaminants in Wells 6 and 7 which are in the pollutant plume being drawn to the Ranney Wells, than in Wells 8 and 9, which are on the fringes of the plume. It is apparent, however, that serious ground-water contamination has involved the entire aquifer--the contaminants are not restricted to a particular zone or horizon in the aquifer.

In order to assure capture of ground-water contaminants in the southwest corner of the plant site by Ranney Wells A and B, it is necessary that these wells continue to be pumped. If the wells are shut down for an extended period the hydraulic gradient, presently west



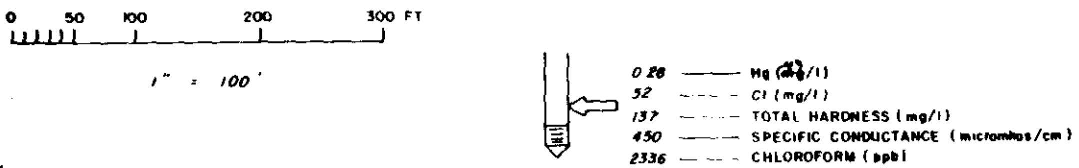


FIGURE 6

GEOLOGIC CROSS SECTION (NORTH - SOUTH)

ALLIED CHEMICAL CORP., MOUNDSVILLE
SOUTH PLANT, WEST VIRGINIA

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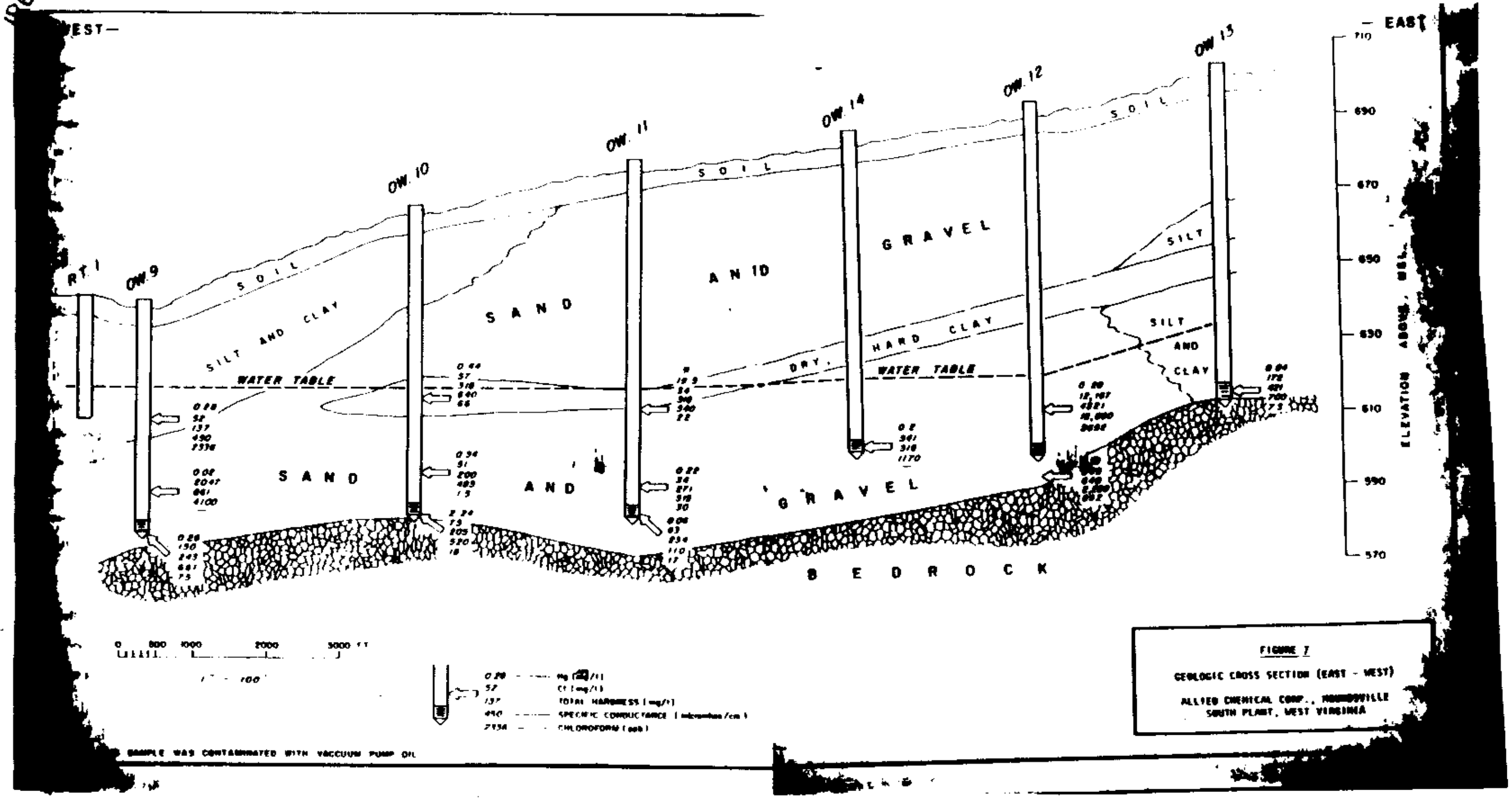

FIGURE 7

GEOLOGIC CROSS SECTION (EAST - WEST)

ALLIED CHEMICAL CORP., MOUNDSVILLE
SOUTH PLANT, WEST VIRGINIA

toward the Ranney Wells, may change toward the south in response to pumpage from the golf course well and Washington Lands Wells, although it is not possible to predict ground-water level changes under such conditions without actually shutting the wells down. Cessation of pumping for short periods of a few days to two weeks for maintenance or other purposes will probably not result in pollutants migrating a great distance off-site. When the wells are returned to service after being shut down for a short period, the renewed pumpage should recapture any contaminants that have traveled beyond the Allied property boundary.

Ground-Water Contamination Problem

Water-quality analyses performed on water samples collected from Ranney Wells in the past, and water-quality data obtained from observation wells installed for this study, show that ground water under most of the site is severely contaminated with both organic and inorganic compounds. The sources of these contaminants are undoubtedly unlined and uncovered waste ponds and piles distributed over the entire plant area. Leachate from these ponds and piles is generated when precipitation percolates through the waste, picking up contaminants that eventually reach ground water after filtering down through the unsaturated soil zone.

It is not possible to determine the areal extent of contamination or to determine the quality or quantity of contaminated water which eventually discharges to the Ohio River without performing a study similar to the one described in the beginning of this report. Most of the polluted water probably discharges to the Ohio River, but a fairly significant quantity may be recovered by the Ranney Wells which is then treated in the treatment plant before reaching the river through a surface outfall. The proportion of recovered water could probably be determined by constructing a flow net, similar to the one shown in Figure 1, for the entire plant site.

The ground-water contamination problem can be alleviated to a large extent with a concomitant decrease in the amount of polluted ground water which discharges to the Ohio River, by severely limiting the amount of contamination which is permitted to enter the ground water. Several remedial steps can be taken in the future to accomplish this task. The first step, which has already been implemented in the case of three ponds recently installed, is to line and seal the bottom and sides of new ponds so that contaminants stored in them cannot escape. Second, abandoned ponds should be graded to a gentle slope or slightly convex, then covered with an impermeable material to prevent precipitation entering the waste, leaching out contaminants, and then conducting them to the water table. This step can be taken because the water table appears to be well below the bottom of the waste ponds (see Tables 3 and NORTH PLANT 4). Finally, an effort should be made to keep all the Ranney Wells pumping continuously, provided the treatment plant is able to accomodate the flow, in order to capture as much contaminated ground-water flow as possible. It might be also worthwhile to consider the installation of a few strategically placed recovery wells to maximize the capture. Pumping the Ranney Wells continuously also has the effect of keeping the water table artifically depressed thereby increasing the distance through which leachate must flow before reaching the water table. The greater the distance leachate must travel, the more natural renovation can occur. This natural renovation can be illustrated by comparing water

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Table 3. Elevations of South Plant Pond Bottoms in Relation to Ground Water Levels.

Pond No.	Elevation of bottom of pond (feet above mean sea level)	Elevation of ground water level (feet above mean sea level)
1	645	619 - 616
2	654	619 - 617
3	656	619 - 618
4	671	620 - 619
Mercury Removal	663	-
Water Treatment Pond	662	-
5	672	-

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Table 4. Elevations of North Plant Pond Bottom in Relation to Ground Water Levels.

Pond No.	Description	Elevation of bottom of pond (feet above mean sea level)	Elevation of ground water level[1)] (feet above mean sea level)
1	Orig. settling	625	-
2	Formaldehyde Treat.	625	-
3	Bldng S2 Water	630.5	-
4	Fire	651.8	-
5	O.F. #2 Equal	-	-
	O.F. #3	~630	-
7	Equalization	629 - 630	615 - 609
8	Settling	629 - 630	618 - 612

1) As measured on 8-24-77.

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quality data for a leachate spring (see Sample 0-1 in Table 2) and for Observation Well 5 (Samples 7-1 and 7-2 in Table 2). The quality of the spring is probably indicative of leachate generated in the waste ponds and is of a much inferior quality than the ground water immediately beneath the ponds.

Respectfully submitted,

GERAGHTY & MILLER, INC.

Nicholas Valkenburg

Nicholas Valkenburg
Hydrogeologist

George R. Wilson

George R. Wilson
Vice President

NV:GW:lcc

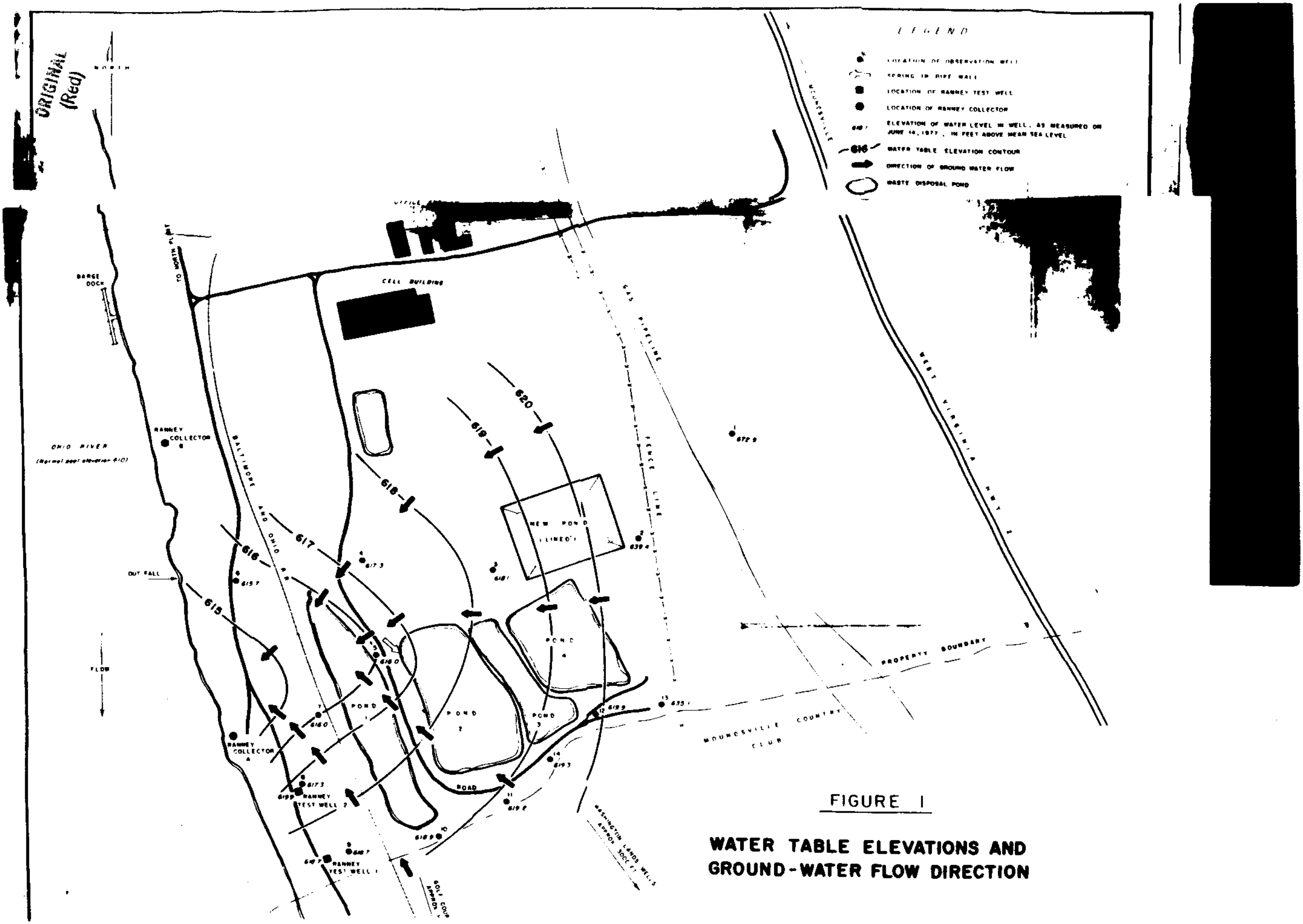

FIGURE 1

WATER TABLE ELEVATIONS AND GROUND-WATER FLOW DIRECTION

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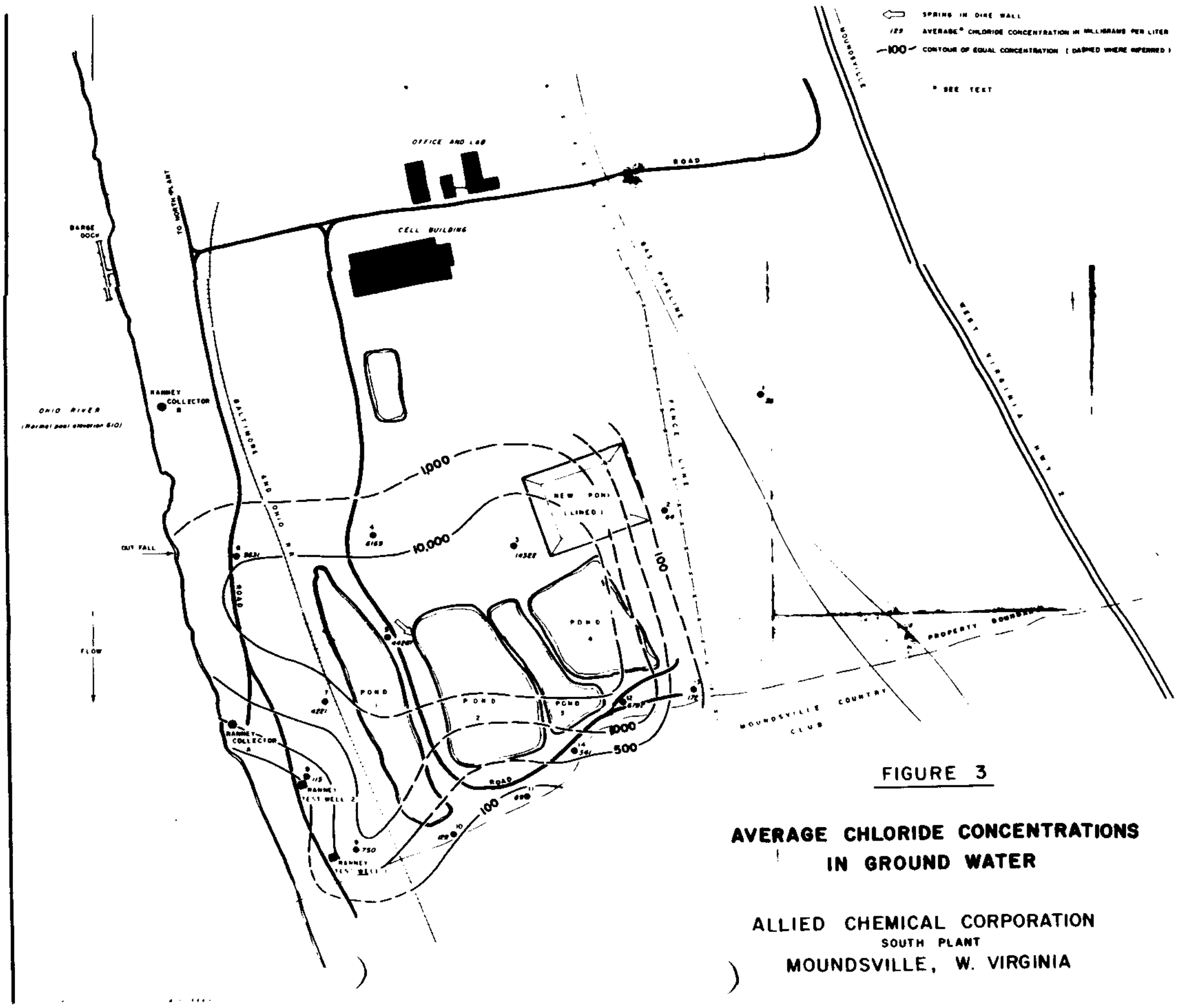

FIGURE 3

AVERAGE CHLORIDE CONCENTRATIONS IN GROUND WATER

ALLIED CHEMICAL CORPORATION
SOUTH PLANT
MOUNDSVILLE, W. VIRGINIA

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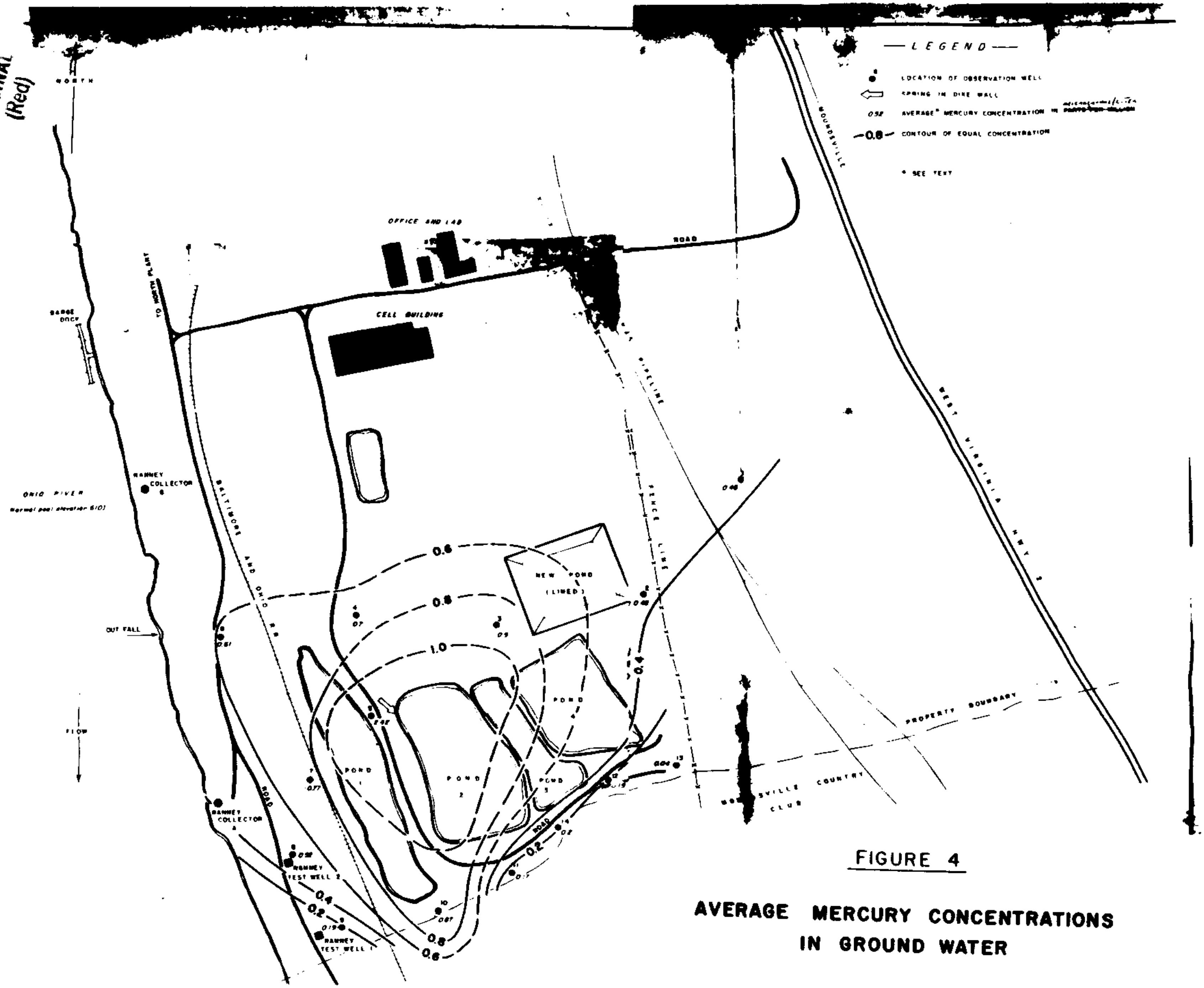

FIGURE 4

AVERAGE MERCURY CONCENTRATIONS IN GROUND WATER

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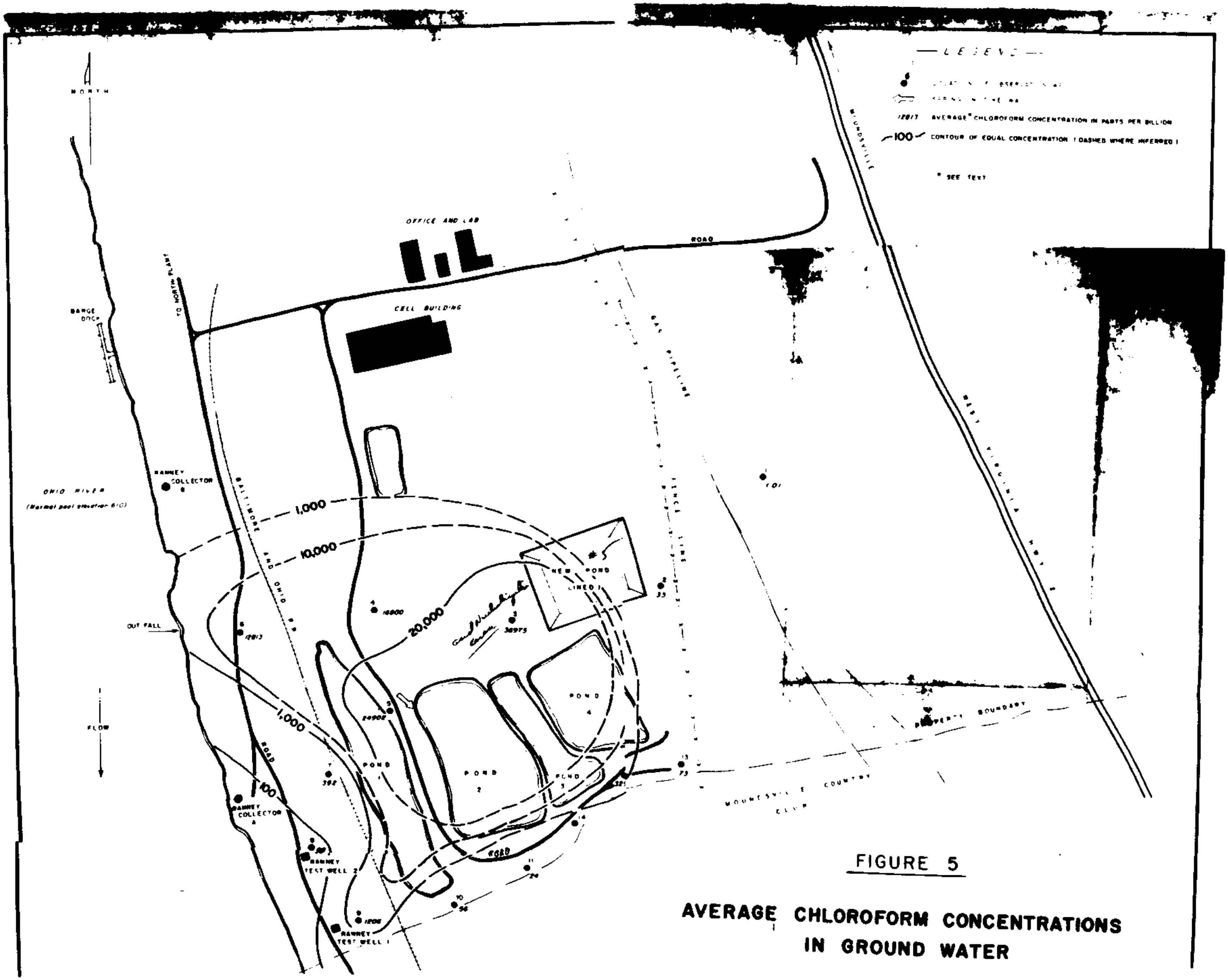

FIGURE 5

AVERAGE CHLOROFORM CONCENTRATIONS IN GROUND WATER